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EXTENDED ABSTRACT

Age and sex differences in a virtual version of the reorientation task

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Introduction

Previous studies on allocentric frame of reference (FoR) have shown a substantial deficit in elderly spatial navigation. (e.g. Moffat and Resnick 2002). We referred to allocentric FoR in terms of the absence of reckoning cues in solving a spatial navigation task. Although age-related effect on navigational behaviour has been already evaluated in previous studies (e.g. Driscoll et al. 2005), rarely the impact of both layout and featural information has been systematically assessed. Acquisition and use of knowledge regarding the environment are fundamental to effective everyday functioning and, consequently, have a critical impact on the quality of life, particularly for elderly adults. A general aim of this study is to investigate the different weight of layout and featural information in a virtual version of reorientation paradigm (VReor) adopting an individual difference perspective. Virtual environments have been successfully employed in research involving both children (e.g. Newhouse et al. 2007) and elderly (Moffat and Resnick 2002). Benefits in the employment of virtual reality technologies can be summed as follows: (a) improvement in experimental control, with the advantage to create realistic, interactive three-dimensional environments, and to collect a large amount of reliable data, (b) maintained ecological validity with respect to real-world settings, (c) opportunity to investigate spatial navigation strategies in samples showing different characteristics, such as aged people and people with cognitive impairments and psychopathological conditions. In line with the aforementioned theoretical framework, this paper accounted for the following ideas: first, the layout information remains stable along life-span, because it seems to be linked to a more implicit perception of space, the use of featural information is less stable along life-span, and it tends to corrupt earlier with age. Second, males rely predominantly on layout information, while featural information is used equally by both males and females.

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Method

Participants

One hundred and fifty-five participants voluntarily took part in the experiment. They were recruited within lifelong learning Institutions (Third Age Universities) in Apulia (South-East of Italy) and received a little gift for participating. The vision of all participants was normal or corrected to normal. They took part in the experiment after they had given their written consent. The data of four participants (two old adults and two very old adults) were excluded from the analyses since they did not reach the proficiency in a pre-experimental screening test. The experimental sample is composed of four groups: (a) 40 young adults (17 women and 23 men), ranging in age from 20 to 39 years (mean = 27.3, SD = 6.1), (b) 40 middle adults (20 women and 20 men), ranging in age from 40 to 59 years (mean = 53.6, SD = 5.4), (c) 37 old adults (22 women and 15 men), ranging in age from 60 to 69 years (mean = 64.4, SD = 2.8), (d) 34 old-old adults (20 women and 14 men), ranging in age from 70 to 80 years (mean = 74.7, SD = 3.3).

Apparatus and material

A series of three-dimensional navigable virtual environments were presented on a 21-in. computer monitor. Freeware software, the C-G Arena was used to generate two types of environments: (a) a rectangular environment measuring 180 × 120 × 60 units, with four white walls (coded as L = layout information), (b) a square environment measuring 120 × 120 × 60 units, with three white walls and a blue wall on one of the sides (coded as F = featural information). Participants used a joystick to explore the virtual environments.

Procedure

Pre-experimental screening test

Prior to the start of the experiment, Mini-Mental State Examination and a reference memory test were submitted to the participants, in order to assess their cognitive functionality. The reference memory test had the same structure of the experimental task with the exception that the target was presented always in the same position across three repetitions for each environment. If the participants scored less than 26 or 27 in MMSE, if they had less or unless 9 years of education, respectively, or they were induced in more than one error per environment in reference memory test, they were excluded from the experimental sample. Three participants scored less than the criteria in MMSE and one scored three in the reference memory test.

Experimental session

After overcoming pre-experimental screening test, participants were involved in a virtual navigation task. Experimental session was composed of ten trials. Each trial was composed of a learning phase in which a target (a yellow sphere) was visible, and a testing phase in which the target was hidden. Trials were presented in two blocks of five trials each, one block for each type of environment: order of the blocks was balanced.

Participants faced both (a) a rectangular environment with four white walls and (b) a square environment with three white walls and a blue wall on one of the sides. Target was located in one of the corners. They were requested to explore the learning environment, looking for the yellow sphere, and then they were teleported into the testing environment, where their task was to find the yellow sphere, hidden in one of four blue boxes, but not moved from the original location previously seen. They were also informed that their entry point of view (POV) in the testing environment could vary randomly with respect to the one they had in learning environment, perturbing the egocentric mental representation of the relative position of the target with respect to participants' view.

Response coding

In rectangular environment with four white walls the responses were recorded as appropriate if the participants searched either at the correct corner "C" or at its rotationally equivalent "R" corner. In the square blue-wall environment the responses were recorded as appropriate if the participants searched at the correct corner "C".

Results

We reported two separate factorial analysis of variance (ANOVA) on accuracy (number of correct responses) in both *layout* and *featural* conditions. Partial eta square and approximate *P*rep were also reported for the significant effects. Interaction effects (age × gender) had been, however, assessed even when they did not reach significance in order to verify some partial effects. Preliminarily a one-way ANOVA was performed on *pre-experimental screening test* in order to evaluate differences among groups on MMSE scoring. The analysis revealed an expected effect of age $F(3,\ 143) = 10.49$ $P < 0.001$, $\eta_p^2 = 0.17$, approx. *P*rep = 0.99. Post hoc Sheffè test showed that the first two groups performed significantly better with respect to the old and old-old participants (see Table 1).

Layout condition

A 2 × 4 ANOVA was carried out on accuracy in testing phase, with gender (male, female) and age (young, middle, old and old-old adults) as independent variables. The main effect of gender, favouring men emerged, $F(1,\ 143) = 10.057$, $P < 0.001$, $\eta_p^2 = 0.07$, approx. *P*rep = 0.99. Assessing non-significant interaction effect ($F < 1$) via planned comparison, gender differences effect resulted particularly marked in the old-old adults, $F(1, 143) = 12.32$, $P < 0.005$, $\eta_p^2 = 0.08$, approx. *P*rep = 0.97. The main effect of age was not statistically significant ($F < 1$) suggesting that the ability elaborating geometrical information in the environment remained intact across age.

Featural condition

A 2 × 4 ANOVA was carried out on accuracy in testing phase, with gender (male, female) and age (young, middle, old and old-old adults) as independent variables. The main effect of age emerged, $F(3,\ 143) = 5.43$, $P < 0.001$, $\eta_p^2 = 0.10$, approx. *P*rep = 0.99. As revealed by the Scheffé post hoc test, old-old adults performed worser than

Table 1 Mean (standard errors) of accuracy as effect of age, gender and kind of environment (layout only and featural only), as recorded in the testing phase

	Age groups (years)							
	Young (20–39)		Middle (40–59)		Old (60–69)		Old-old (70–79)	
	Female	Male	Female	Male	Female	Male	Female	Male
Layout only	4.29 (0.19)	4.65 (0.16)	4.30 (0.18)	4.50 (0.18)	4.32 (0.17)	4.47 (0.21)	3.65 (0.18)	4.64 (0.21)
Featural only	4.65 (0.20)	4.70 (0.17)	4.20 (0.18)	4.20 (0.18)	4.05 (0.17)	4.40 (0.21)	3.65 (0.18)	4.14 (0.22)

Accuracy is referred to the number of correct searches (max = 5)

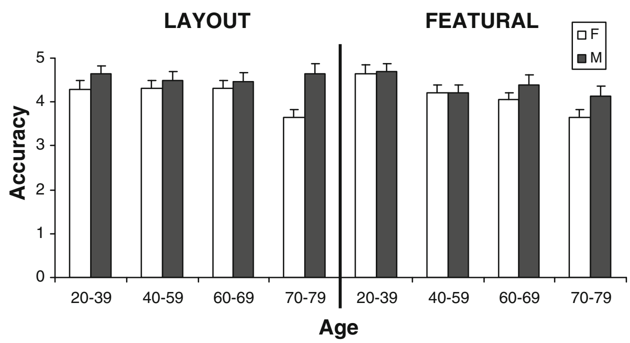

Fig. 1 Mean and standard error (*in bars*) of accuracy as effect of age and gender in each kind of environment (layout and featural), as recorded in the testing phase. Accuracy is referred to the number of correct searches (max = 5)

young adults ($P < 0.001$); differences between old-old adults and the other two groups failed to reach statistical significance (middle $P < 0.09$; old $P < 0.08$). The effect of gender was not significant ($F > 1$) suggesting that when landmark is available women perform as well as men. Again, age × gender effect was not significant ($F > 1$) revealing that age differences in elaborating featural information was similar for both men and women (Fig. 1).

Discussion

It is generally assumed that aged with respect to young adults encounter more difficulties in orienting themselves in a novel environment, especially when allocentric spatial processing is required (Moffat and Resnick 2002). Adopting the VReor paradigm (e.g. Bosco et al. 2008), in which egocentric trace is perturbed by a disorientation procedure, we promote a new methodology to assess virtual spatial navigation based on purely external visual cues. Two kinds of information affect primarily performance in navigational tasks: layout and featural information. Thus, the main aim of this study was to evaluate behavioural changes in spatial navigation as effect of different spatial cues, gender and normal aging. Our results revealed that age differences did not appear when the recognition of a place is guided by layout processes, suggesting their slower cognitive decline with respect to those based on featural ones. This result might be explained within the implicit/explicit information processing framework (e.g. Tulving 2000). According to Doeller et al. (2008) learning locations on the basis of the layout is supported by implicit processes. In addition, Fodor's (2000) modularity approach claims that geometric module, which is deputed to the encoding of spatial layout, underlies unconscious or implicit perception of the space. On the contrary, featural information is supposed to have a more clearly declarative status (Golledge and Stimson 1997). Previous studies suggested that there is relatively little age-related changes in tasks involving implicit learning (e.g., Howard and Howard 1997). In addition, studies on procedural/non-declarative memory tasks indicated that age-related changes are relatively small if compared to declarative tasks (see LaVoie and Light 1994, for a review). In the present study, older adults showed a decline in the ability to use featural information which are supported by a explicit/declarative processing, nonetheless they performed as well as younger adults if layout information were available. With regard to gender-related effect, our overall results confirmed a well established effect in the literature on gender-related differences (e.g. Saucier et al. 2002) revealing a male advantage if orientation was based on layout cues and a lack of differences if orientation was guided by featural information. Taken together, these results demonstrated that VReor paradigm is perfectly suitable for understanding basic modification of spatial behaviour as the effect of gender- and age-related individual differences.

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